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**Kitajima et al.**

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(54) **LIGHT EMITTING DEVICE**  
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(2013.01);  
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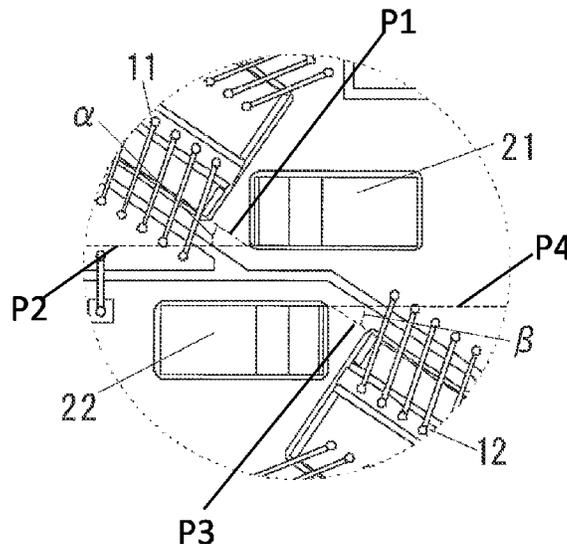
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(57) **ABSTRACT**  
A light emitting device includes: a base; a first semiconductor laser element disposed on an upper surface of the base and configured to emit first light; a first light reflecting member disposed on the upper surface of the base, the first light reflecting member having a first light reflecting face including a plane configured to reflect the first light; a second semiconductor laser element disposed on an upper surface of the base and configured to emit second light; a second light reflecting member disposed on the upper surface of the base, the second light reflecting member having a second light reflecting face including a plane configured to reflect the second light; and a phosphor member onto which the first light reflected from the first light reflecting member and the second light reflected from the second light reflecting member are irradiated.

**16 Claims, 10 Drawing Sheets**



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**H01S 5/00** (2006.01)  
**F21Y 115/30** (2016.01)  
**H01S 5/02216** (2021.01)  
**H01S 5/40** (2006.01)

- (52) **U.S. Cl.**  
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(2013.01)

- (58) **Field of Classification Search**  
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F21K 9/23; F21K 9/68; F21V 7/10; F21V  
13/10; F21V 11/16; F21Y 2115/30  
See application file for complete search history.

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Fig. 1

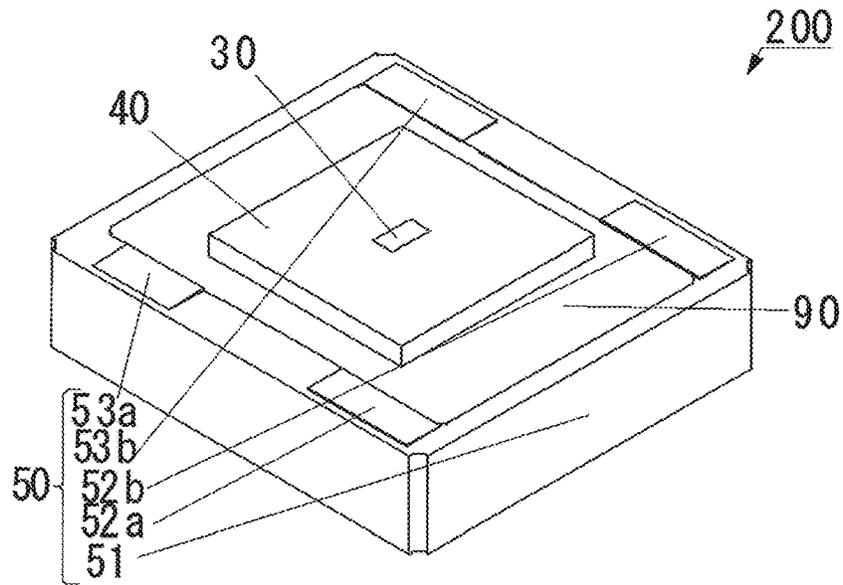


Fig. 2

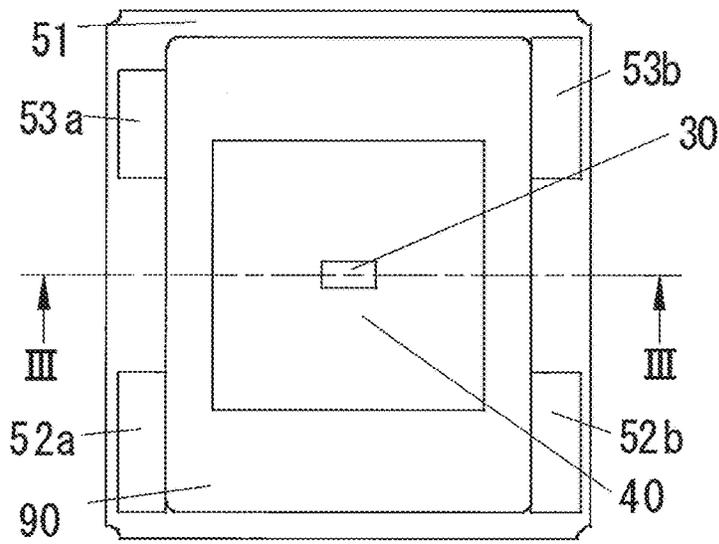


Fig. 3

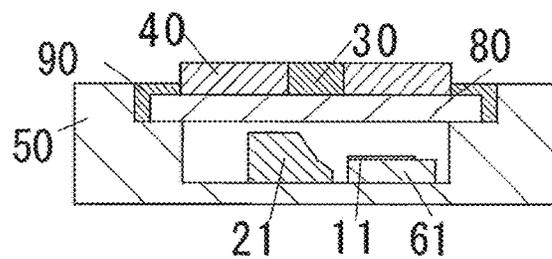


Fig. 4

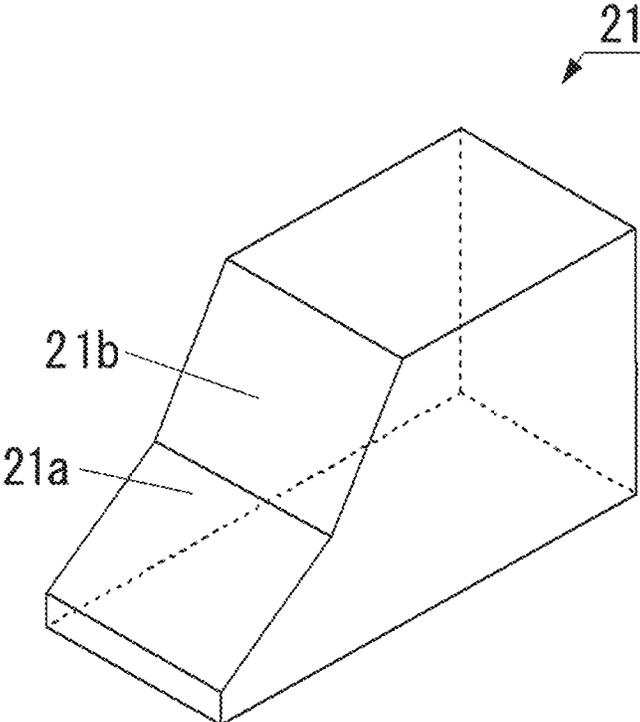


Fig. 5

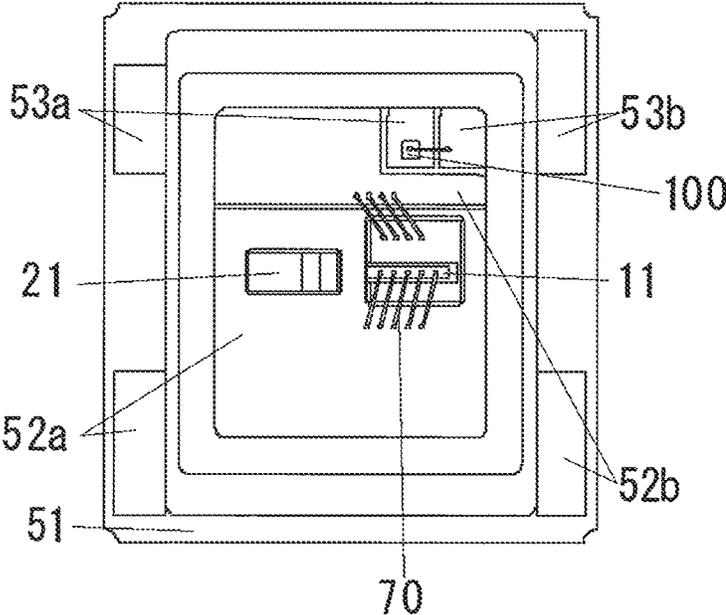


Fig. 6

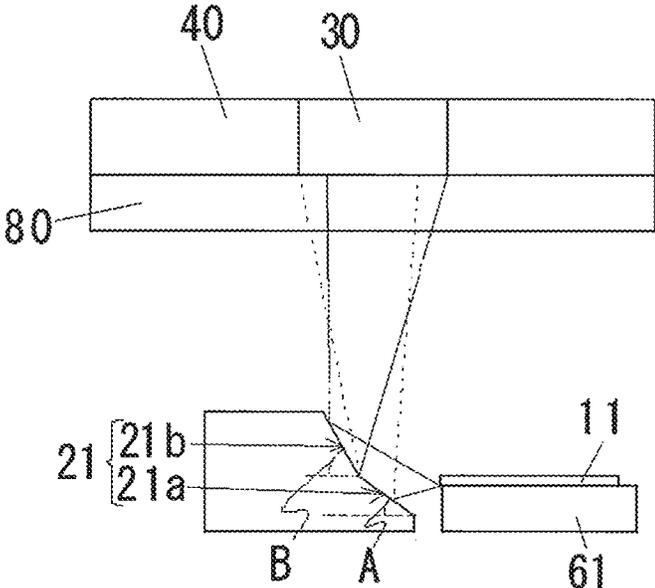


Fig. 7

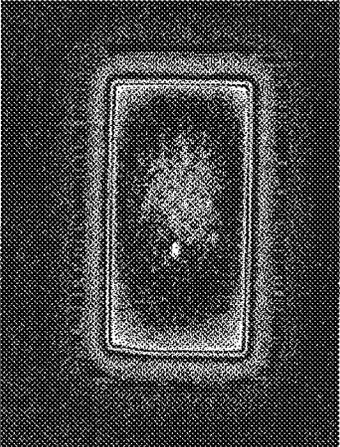


Fig. 8

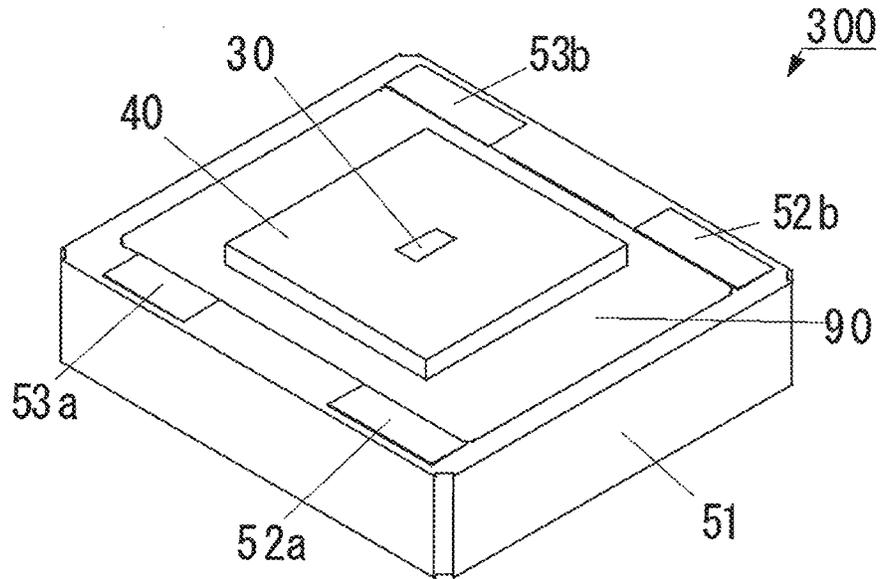


Fig. 9

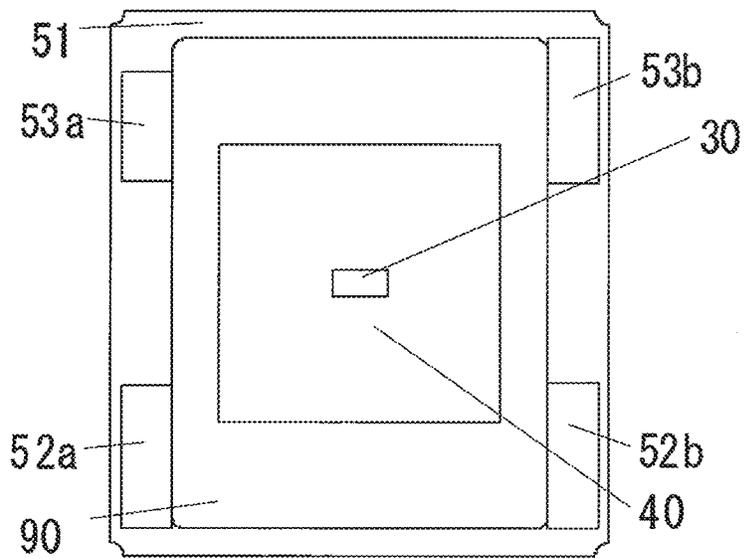


Fig. 1 0

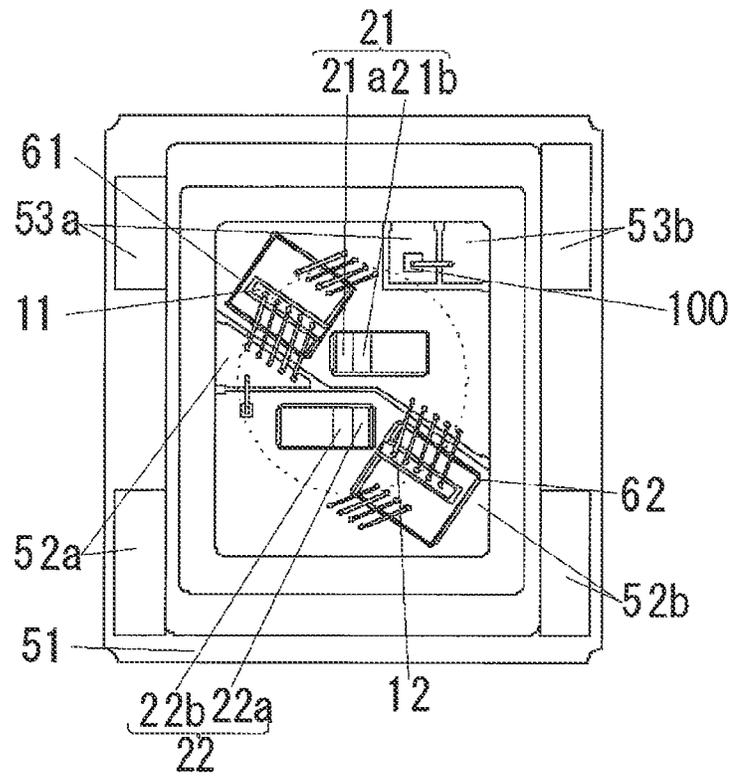
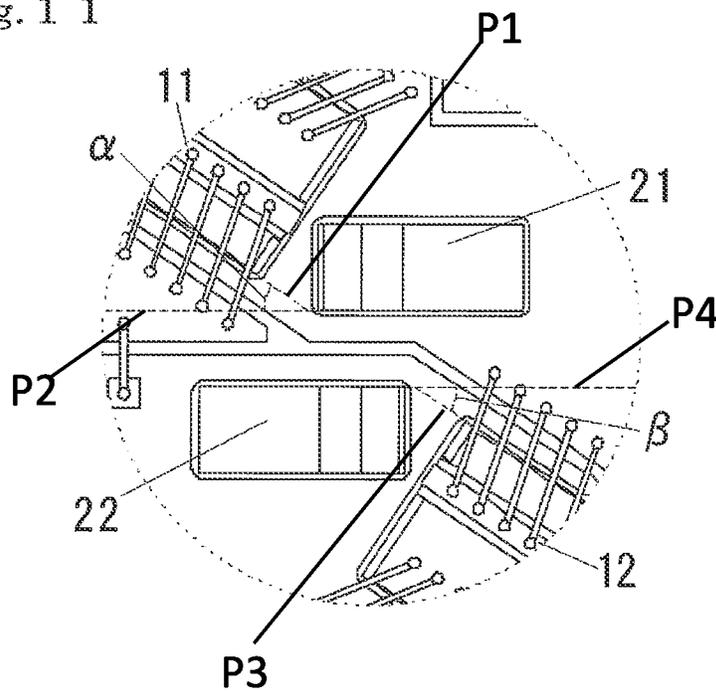


Fig. 1 1



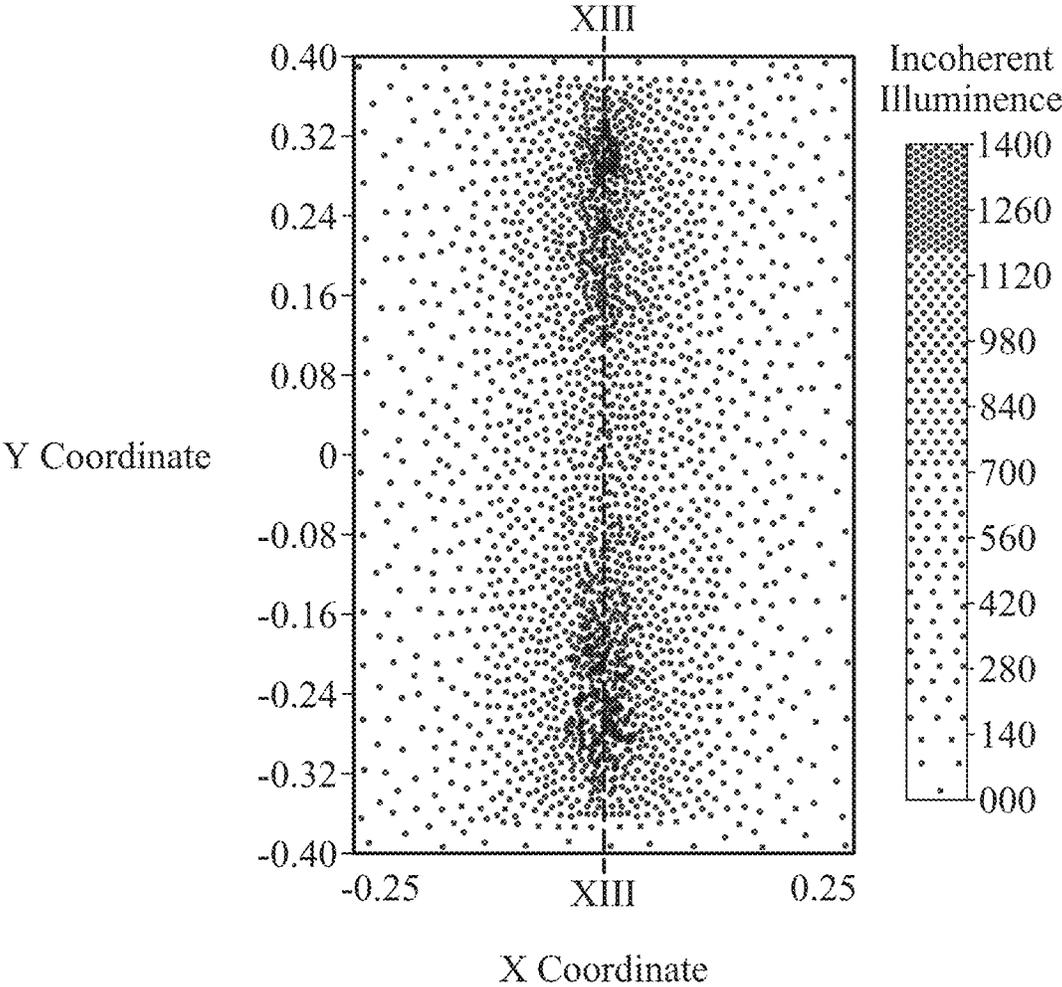
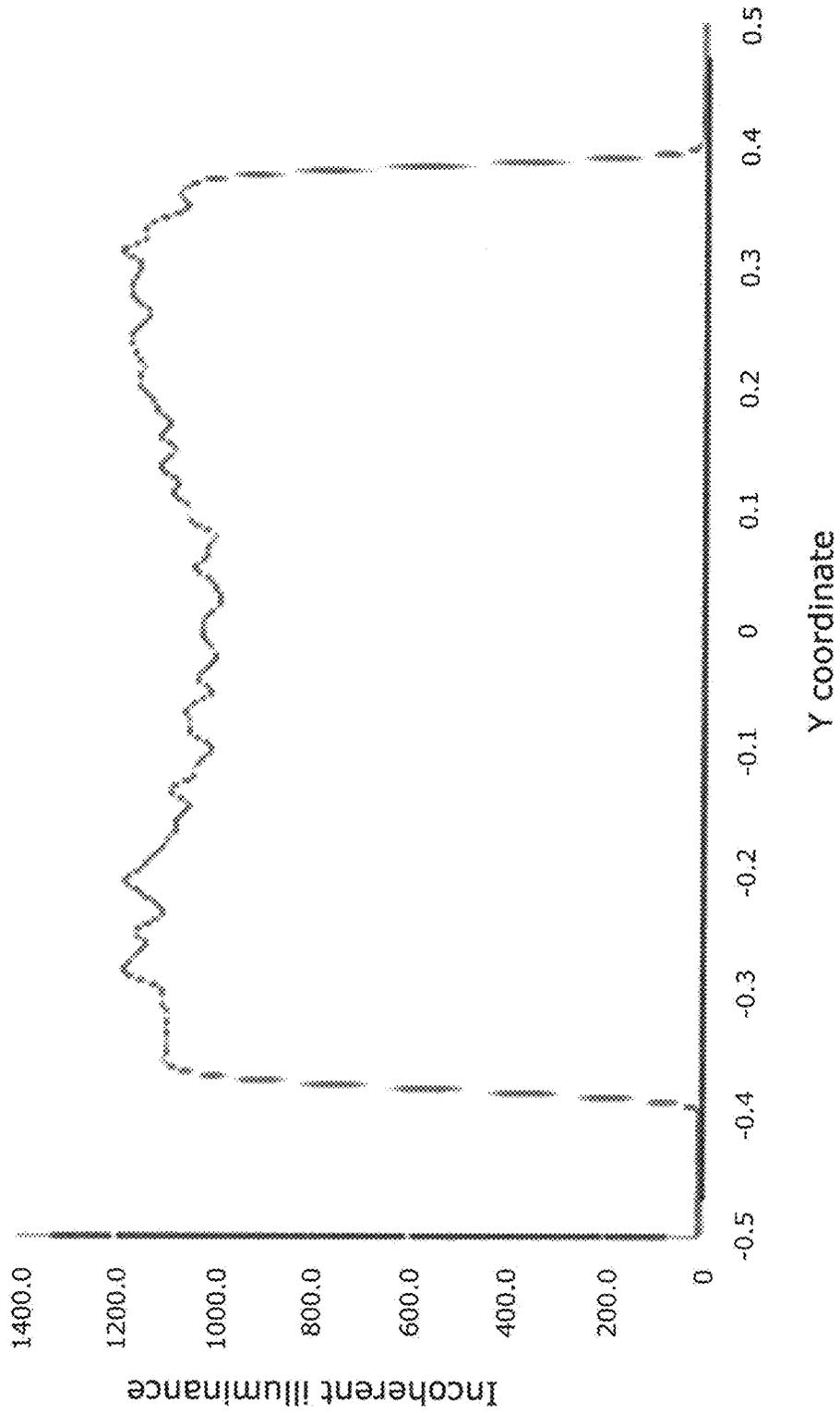


FIG. 12

Fig.13



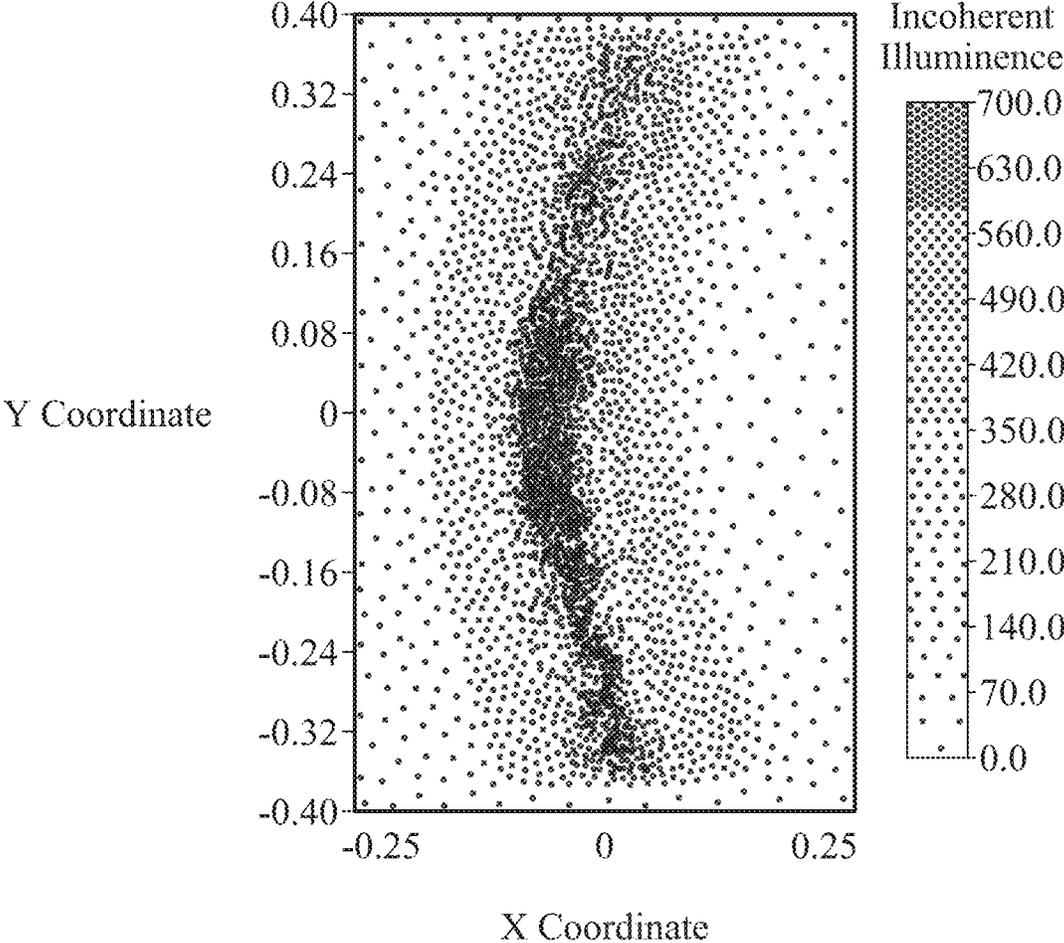


FIG. 14

Fig. 1 5

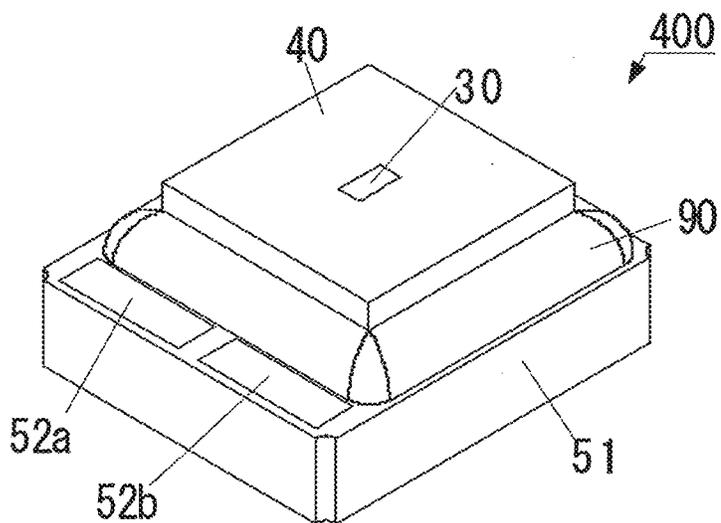


Fig. 1 6

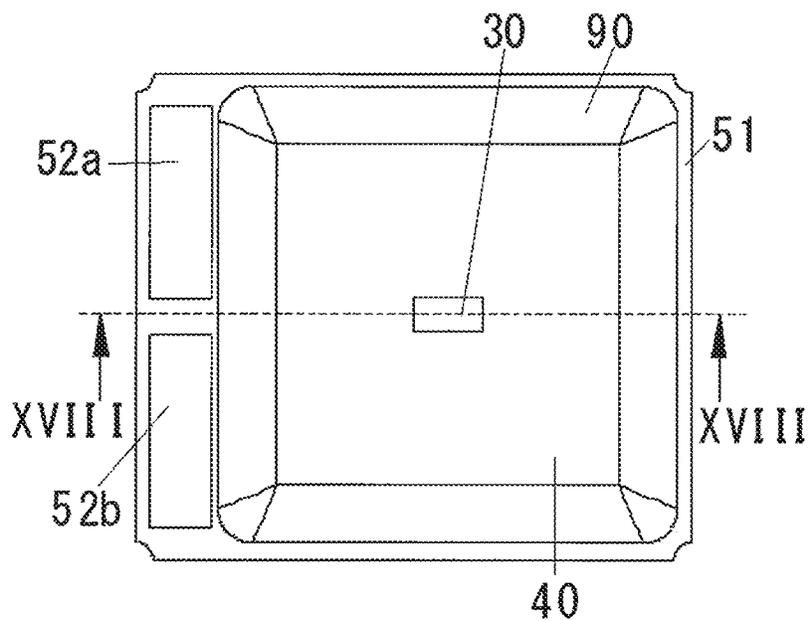


Fig. 1 7

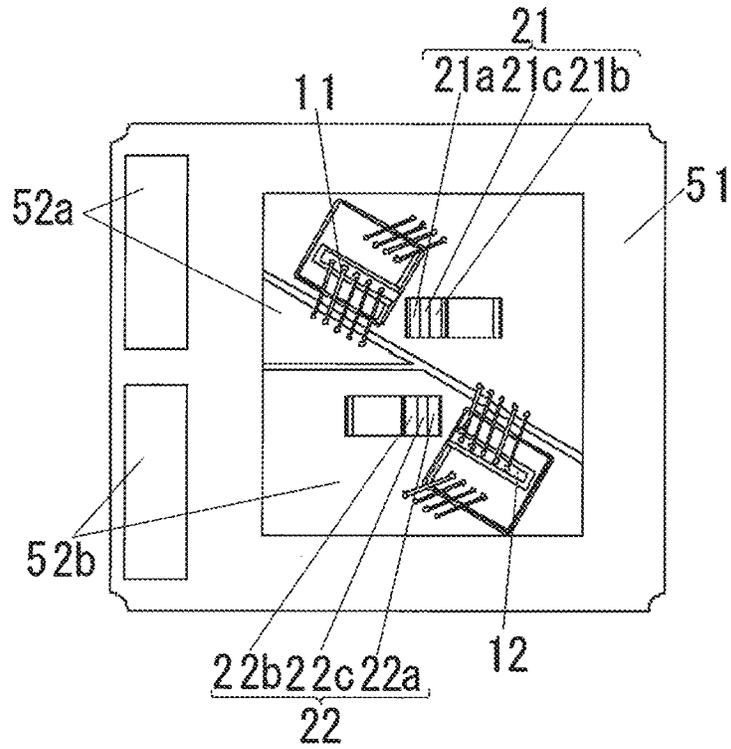
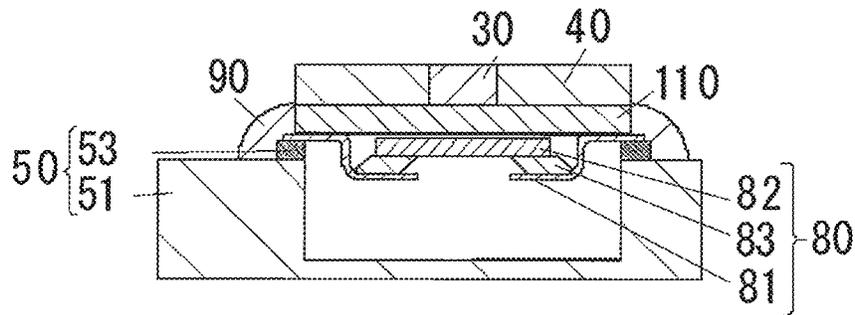


Fig. 1 8



## LIGHT EMITTING DEVICE

## CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. patent application Ser. No. 16/259,989, filed on Jan. 28, 2019, which claims priority to Japanese Patent Application No. 2018-013695, filed on Jan. 30, 2018, the disclosures of which are hereby incorporated by reference in their entireties.

## BACKGROUND

The present disclosure relates to a light emitting device. There is known a light emitting device that includes multiple semiconductor laser elements, a light reflecting member having multiple light reflecting surfaces, a phosphor member disposed above the light reflecting member, and a light shielding member disposed on the lateral sides of the phosphor member. See, for example, FIG. 27 of PCT Publication No. 2012-512508.

## SUMMARY

There are cases where the intensity of the emitted light irradiated on the lower surface of the phosphor member is higher in the central portion of the light emitted from the laser element than the area surrounding the central portion. In this case, because a large amount of heat is generated in the region of the phosphor member irradiated by the central portion of the light emitted from the laser element, the conversion efficiency of the phosphor member will likely decline. Furthermore, emission intensity non-uniformity may occur in the light extracted from the phosphor member.

In one embodiment of the present disclosure, a light emitting device includes: a base; a first semiconductor laser element disposed on an upper surface of the base and emitting first light; a first light reflecting member disposed on the upper surface of the base and reflecting the first light upwards; a phosphor member having a lower surface onto which the first light is irradiated, and an upper surface serving as the light extraction surface; and a light shielding member disposed to surround lateral surfaces of the phosphor member. The first light reflecting member includes a first region onto which a portion of the first light is irradiated, and a second region positioned farther from the first semiconductor laser element than the first region, the second region onto which another portion of the first light is irradiated. The first region and the second region are formed so that the portion of the light reflected by the first region that is reflected on a side close to the second region and the portion of the light reflected by the second region that is reflected on a side close to the first region intersect before reaching the lower surface of the phosphor member, to thereby irradiate both end portions in a longitudinal direction of the irradiated region in the lower surface of the phosphor member.

With the light emitting device described above, the conversion efficiency decline of the phosphor member can be attenuated while reducing non-uniformity in the emission intensity of the light extracted from the phosphor member.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the light emitting device related to a first embodiment.

FIG. 2 is a top view of the light emitting device related to the first embodiment.

FIG. 3 is a cross-sectional view taken along line in FIG. 2.

FIG. 4 is a perspective view of the first light reflecting member of the light emitting device related to the first embodiment.

FIG. 5 is a schematic diagram illustrating the interior of the recess of the base in the light emitting device related to the first embodiment.

FIG. 6 is a schematic diagram explaining the paths of the first light from the first semiconductor laser element that irradiates the lower surface of the phosphor member after being reflected by the first light reflecting member in the light emitting device related to the first embodiment.

FIG. 7 shows the emission intensity distribution data measured at the phosphor member when irradiating the phosphor member with light having a relatively uniform luminous intensity.

FIG. 8 is a perspective view of the light emitting device related to a second embodiment.

FIG. 9 is a top view of the light emitting device related to the second embodiment.

FIG. 10 is a schematic diagram illustrating the interior of the recess of the base in the light emitting device related to the second embodiment.

FIG. 11 is an enlarged view of the section encircled by the dotted line in FIG. 10.

FIG. 12 shows the simulation data of the luminous intensity distribution of the first light and the second light irradiated onto the lower surface of the phosphor member.

FIG. 13 shows the luminous intensity distribution along the straight line XIII-XIII in FIG. 12.

FIG. 14 shows the simulation data of the luminous intensity distribution of the first light irradiated onto the lower surface of the phosphor member.

FIG. 15 is a perspective view of the light emitting device related to a third embodiment.

FIG. 16 is a top view of the light emitting device related to the third embodiment.

FIG. 17 is a top view illustrating the interior of the recess of the light emitting device related to the third embodiment.

FIG. 18 is an end view taken along XVIII-XVIII in FIG. 16.

## EMBODIMENT

Certain embodiments of the present disclosure will be explained with reference to the accompanying drawings. However, the embodiments described below are for giving shape to the technical ideas of the present disclosure, and are not intended to limit the present invention. The sizes and positional relationships of the members shown in the drawings might be exaggerated for clarity of explanation. The light extraction side (i.e., the upper side in FIG. 3) of the light emitting device herein is referred to as above/upper/upwards, and the opposite side (i.e., the lower side in FIG. 3) will be referred to as below/lower/downwards.

## First Embodiment

FIG. 1 is a perspective view of the light emitting device 200 related to a first embodiment. FIG. 2 is a top view of the light emitting device 200. FIG. 3 is a cross-sectional view taken along III-III in FIG. 2. FIG. 4 is a perspective view of the first light reflecting member 21 included in the light emitting device 200. FIG. 5 is a top view illustrating the

interior of the recess of the base **50**. FIG. 6 is a schematic diagram showing the paths of the first light from the first semiconductor laser element **11** (hereinafter the “semiconductor laser element” will also be referred to as “laser diode element” or “LD element”) irradiated onto the lower surface of the phosphor member **30** after being reflected by the first light reflecting member **21**.

As shown in FIG. 1 to FIG. 6, the light emitting device **200** includes a base **50**, a first LD element **11** disposed on an upper surface of the base **50** and emitting first light, a first light reflecting member **21** disposed on the upper surface of the base **50** and reflecting the first light upwards, a phosphor member **30** having a lower surface onto which the first light is irradiated and an upper surface serving as the light extraction surface, and a light shielding member **40** disposed to surround the lateral surfaces of the phosphor member **30**. The first light reflecting member **21** includes a first region **21a** onto which a portion of the first light is irradiated, and a second region **21b**, positioned farther from the first LD element **11** than the first region **21a**, the second region onto which another portion of the first light is irradiated. The first region **21a** and the second region **21b** are formed so that the portion of the light reflected by the first region **21a** that is reflected on a side close to the second region **21b** and the portion of the light reflected by the second region **21b** that is reflected on a side close to the first region **21a** intersect before reaching the lower surface of the phosphor member **30**, to thereby irradiate both end portions in a longitudinal direction of the irradiated region in the lower surface of the phosphor member **30**.

The light emitting device **200** can achieve reduction in the emission intensity non-uniformity of the light extracted from the phosphor member **30**, and attenuation of the conversion efficiency decline of the phosphor member **30**. This will be explained in detail below.

In the case of a conventional light emitting device, the light from the first LD element has higher luminous intensity in the central portion than the portions distant from the central portion (near the outer edges) of the irradiated region in the lower surface of the phosphor member. In a conventional light emitting device, for example, the light emitted from the LD element is reflected by the light reflecting surface, which is slanted at 45 degrees from a line perpendicular to the top surface of the base, to irradiate the lower surface of the phosphor member. At this time, the lower surface of the phosphor member is irradiated while the luminous intensity distribution is being maintained. In this case, because the amount of heat generated in the high luminous intensity region of the phosphor member is larger than the amount of heat generated in the areas surrounding this region, the conversion efficiency of the phosphor member is reduced. The differences in intensity of the light irradiated onto the phosphor member likely causes non-uniformity in the intensity of light extracted from the phosphor member.

Accordingly, the light emitting device **200** is designed so that the luminous intensity of the first light in the center of the irradiated region is not excessively higher than the luminous intensity at the end portions of the irradiated region of the lower surface of the phosphor member **30** (i.e., the region onto which light from one or more LD elements is irradiated). Specifically, as shown in FIG. 6, the first light reflecting member **21** has a first region **21a** and a second region **21b** so that the high intensity portion of the light reflected by the first region **21a** (i.e., the light reflected near the left end of the first region **21a** shown in FIG. 6) and the high intensity portion of the light reflected by the second

region **21b** (i.e., the light reflected near the right end of the second region **21b** shown in FIG. 6) intersect before being irradiated onto the lower surface of the phosphor member **30**, to thereby irradiate the regions near the light shielding member **40** in the irradiated region. It is believed that because this can reduce the emission intensity at the center in the irradiated region of the phosphor member **30** so as not to be excessively high, a light emitting device with reduced emission intensity non-uniformity at the phosphor member **30** and attenuated conversion efficiency decline at the phosphor member **30** can be achieved. In the present specification, the first LD element **11** is disposed so that the “high luminous intensity region” of the light emitted from the first LD element **11** irradiates the interface between the first region **21a** and the second region **21b**. The “high luminous intensity region” in the present specification refers to the portion having at least 70% luminous intensity in the far field pattern (FFP) assuming that the lowest region is 0% and the highest region is 100%. The “FFP” in the present specification shows luminous intensity distribution of the first light measured at a plane that is located at a certain distance from and parallel to the emission surface of a LD element, and is identified as the shape at a given intensity, for example,  $1/e^2$  of the peak intensity value.

The constituent elements of the light emitting device **200** will be explained below.

#### Base **50**

The base **50** is a member on which a first LD element **11** is mounted. In the present embodiment, a base **50** having a recess is used, and the first LD element **11** is disposed on the upper surface of the base **50** in the recess (i.e., the first upper surface that forms the bottom of the recess).

The recess of the base **50** has a first upper surface, and a second upper surface that is located higher than the first upper surface and inside the recess. In other words, the recess has a second upper surface and a third upper surface upwardly stepwise from the first upper surface. The first upper surface, the second upper surface, and the third upper surface are substantially parallel to the lower surface of the base **50**. A cover **80** formed of a material comprising a light transmissive material is placed on the second upper surface, and the phosphor member **30** and the light shielding member **40** are secured to the upper surface of the cover **80**. For the base **50**, one having no second upper surface may be used. In this case, the cover **80** is disposed on the surface corresponding to the third upper surface of the base **50**.

As shown in FIG. 5, the base **50** with a recess has a main body **51** formed of an insulator, wiring parts **52a** and **52b** each exposed from the main body **51** and disposed on the third upper surface and the first upper surface of the base **50**, second wiring parts **53a** and **53b** each exposed from the main body **51** and disposed on the third upper surface and the first upper surface of the base **50** and electrically connected to a thermistor **100**, and a metalized part exposed from the main body **51** at the second upper surface. By exposing each of the wiring parts **52a** and **52b** and each of the second wiring parts **53a** and **53b** that will be externally electrically connected at the surfaces other than the lower surface of the main body **51**, the entire lower surface of the base **50** can be used as the surface to be mounted on a heat dissipating member, such as a heat sink. This facilitates dissipation of the heat generated by the light emitting device to the heat dissipating member.

For the main body **51**, a material comprising a ceramic as a main component may be used. Examples of ceramics include aluminum oxide, aluminum nitride, silicon nitride, or silicon carbide. Among such examples, a material com-

prising aluminum nitride as a main component is preferably used for the main body **51** from a heat dissipation perspective. For the wiring parts **52a** and **52b** and the second wiring parts **53a** and **53b**, metal materials, such as gold, silver, aluminum, palladium, or the like may be used. For the metalized part, metal materials such as gold may be used.

For the base **50**, one having a base part and a frame part disposed on the upper surface of the base part may alternatively be used. In this case, the first LD element **11** is disposed on the upper surface of the base part inside the frame part. When using a base **50** having a base part and a frame part, the wiring parts **52a** and **52b** are preferably disposed on the upper surface of the base part on the outside of the frame part in consideration of the heat dissipation properties of the light emitting device.

First Semiconductor Laser Element **11**

The first light emitted from the first LD element **11** has an oval-shaped FFP that has a larger length in the stacking direction of the multiple semiconductor layers including an active layer than the direction perpendicular thereto in a plane parallel to the emission surface of the first LD element **11**. The first LD element **11** is disposed so that its emission surface is perpendicular to the lower surface of the base **50**, and the longitudinal direction of the oval-shaped FFP is perpendicular to the lower surface of the base **50**. This allows the first LD element **11** to be disposed so that its surface having a large surface parallels the lower surface of the base **50**, thereby facilitating dissipation of the heat generated by the first LD element **11** through the base **50** and a heat sink. "Perpendicular" in the present specification may include the slant that can be caused during mounting process. For example, it includes a slant of about plus or minus 10 degrees.

For the first LD element **11**, one having a peak emission wavelength in the range of from 320 nm to 530 nm, typically from 430 nm to 480 nm, can be used. The effect of attenuating the emission intensity non-uniformity can be notably demonstrated because an LD element having a peak emission wavelength within the stated range emits light of relatively high energy that likely causes the conversion efficiency reduction of the phosphor member **30**. For the LD element having a peak emission wavelength within the range stated above, it is preferable to use materials that include a nitride semiconductor, such as one including at least one of GaN, InGaN, and AlGaIn.

The first LD element **11** is mounted on the base **50** via a first submount **61**. This can increase the distance from the emission point in the emission surface of the first LD element **11** to the mounting surface of the base **50** for mounting the first LD element (i.e., the first upper surface in the recess in FIG. 3) by the thickness of the first submount **61**, thereby allowing the emitted light from the first LD element **11** to efficiently irradiate the first light reflecting member **21**. The first LD element **11** can be secured to the first submount **61** using a conductive layer such as Au—Sn.

For the first submount **61**, it is preferable to use a material having a thermal expansion coefficient between the thermal expansion coefficient of the base **50** and the thermal expansion coefficient of the first LD element **11**. This can reduce the delamination of the first LD element **11** and/or the first submount **61**. In the case of using materials comprising a nitride semiconductor as the first LD element **11**, aluminum nitride or silicon carbide, for example, can be used for the first submount **61**.

The first LD element **11** is electrically connected to the wiring parts **52a** and **52b** of the base **50** using wires **70** (fine metal wires).

In the present embodiment, one LD element is disposed on the base, but multiple LD elements may be disposed. In the case of disposing multiple LD elements, the light emitting device is designed so that the intensity of light in the central portion will not be excessively higher than the intensity of light in the end portions of the overall light irradiated onto the irradiated region of the lower surface of the phosphor member.

First Light Reflecting Member **21**

The first light reflecting member **21** reflects the first light emitted from the first LD element **11** towards the phosphor member **30**. By allowing the first light reflecting member **21** to reflect the first light from the first LD element **11** as in the case of the light emitting device **200**, the luminous intensity at the central portion of the first light irradiated onto the irradiated region of the phosphor member **30** can be kept at a level that is not excessively higher while reducing the thickness of the light emitting device **200** (i.e., length in the up and down direction in FIG. 3) as compared to the case in which improvement of uniformity in the emission intensity of the first light is achieved by using a transmissive lens.

Examples of material for the first light reflecting member **21** include a material comprising a heat resistant material as the main material, including quartz, glass such as BK7, metal such as aluminum, or the like. Examples of material for a light reflecting surface of the first light reflecting member **21** include a highly reflective material, such as a metal, dielectric multilayer film, or the like.

The first light reflecting member **21**, as shown in FIG. 6, includes a first region **21a** that is irradiated with a portion of the first light, and a second region **21b** that is positioned farther from the first LD element **11** than the first region **21a** and irradiated with another portion of the first light. The first region **21a** and the second region **21b** are formed so that the portion of the light reflected by the first region **21a** that is reflected on the side close to the second region **21b** and the portion of the light reflected by the second region **21b** that is reflected on the side close to the first region **21a** intersect before reaching the lower surface of the phosphor member **30**, to thereby irradiate both end portions in the longitudinal direction of the irradiated region in the lower surface of the phosphor member **30**.

The first region **21a** and the second region **21b** are preferably provided so that the luminous intensity in the regions near the light shielding member **40** is higher than the luminous intensity in the center of the irradiated region in the lower surface of the phosphor member **30**. In other words, in the irradiated region in the lower surface of the phosphor member **30**, the luminous intensity at both end portions in the longitudinal direction is preferably higher than the luminous intensity in the central portion. FIG. 7 is a photograph showing the luminous intensity distribution measured from the upper surface side of the phosphor member while irradiating the irradiated region with the first light having nearly uniform luminous intensity. As is understood from FIG. 7, even when the first light having nearly uniform luminous intensity is applied to the irradiated region in the phosphor member, the intensity of the light extracted from the areas near the light shielding member (i.e., along the peripheral edges of the phosphor member) was lower than the intensity of light extracted from the area farther from the light shielding member (i.e., the central portion of the phosphor member). This is believed to be caused by the light reflected by the light shielding member concentrating in the central portion. In contrast, it is believed that increasing the luminous intensity of the light in the regions near the light shielding member **40** can make nearly uniform inten-

sity of light extracted from the phosphor member **30**. For example, as shown in FIG. **6**, by allowing the relatively high luminous intensity portion of the light reflected by the first region **21a** to intersect with the relatively high luminous intensity portion of the light reflected by the second region **21b** in their paths so as not to overlap on the lower surface of the phosphor member **30**, the luminous intensity in both end portions in the longitudinal direction of the irradiated region of the phosphor member **30** in the longitudinal direction can be made higher than the luminous intensity in the central portion. The first region **21a** and the second region **21b** may alternatively be formed so that irradiation of light having uniform luminous intensity results in the irradiated region in the lower surface of the phosphor member **30**. Even in this case, the effect can be achieved to some extent as compared to a conventional light emitting device in which the luminous intensity is high in the central portion.

In the light emitting device **200**, the first region **21a** and the second region **21b** are provided to change the luminous intensity distribution only in the longitudinal direction of the oval shape resulting from irradiating the first light reflecting member **21**. In other words, the first region **21a** and the second region **21b** are disposed so that the luminous intensity distribution at the central portion in the longitudinal direction would not become excessively high without changing the luminous intensity distribution along the short-side direction (i.e., perpendicular thereto). A larger effect can be achieved by controlling the luminous intensity distribution in the longitudinal direction because the FFP of the first LD element **11** tends to spread in the longitudinal direction. The luminous intensity distribution in the short-side direction can be changed, but it is preferable to dispose the first region **21a** and the second region **21b** so as to change the luminous intensity distribution only in the longitudinal direction in the oval shape of the first light, in consideration of the production accuracy of the first region **21a** and the second region **21b** of the first light reflecting member **21** as well as the positioning accuracy between the first light reflecting member **21** and the first LD element **11**.

The first region **21a** and the second region **21b** are planar. That is, a light reflecting area of the first light reflecting member **21** are structured with two planar light reflecting surfaces. This not only makes it easier to design the first light reflecting member **21**, but also provides a leeway in the tolerable range for positional displacement when mounting. Furthermore, the first light reflecting member **21** can be more easily formed because the first region **21a** and the second region **21b** are planar. In the present embodiment, the light reflecting area are configured with two planar surfaces, but may be configured with three or more planar surfaces. In the case of achieving a higher luminous intensity in both end portions in the longitudinal direction than the central portion of the irradiated region of the phosphor member **30**, an even number of planes structure the light reflecting area. Moreover, the first region **21a** and the second region **21b** may be curved surfaces.

The angle A formed by a plane parallel to the surface on which the first light reflecting member **21** is mounted (i.e., the first upper surface of the base **50** in the case of the light emitting device **200**) and the first region **21a** is smaller than the angle B formed by a plane parallel to the surface on which the first light reflecting member **21** is mounted and the second region **21b**. The angle A and the angle B are respectively inclined angles of the first region **21a** and the second region **21b** with respect to the plane parallel to the surface on which the first light reflecting member **21** is mounted. For example, the angle formed by the upper

surface of the base **50** and the first region **21a** of the first light reflecting member **21** is larger than 15 degrees, but smaller than 45 degrees, and the angle formed by the upper surface of the base **50** and the second region **21b** of the first light reflecting member **21** is larger than 45 degrees, but smaller than 75 degrees.

#### Cover **80**

The cover **80** when combined with the base **50** creates an airtight space in which the first LD element **11** is disposed. This can reduce the amount of organic substances and dust collected on the emission surface of the LD element. In the present embodiment, the cover **80** made of sapphire is used. A metallized film is formed in the region of the cover **80** to be secured to the base **50**, and is secured to a part of the second upper surface that is also a metallized film by using an Au—Sn solder or the like. Because sapphire is a material that can relatively easily transmit the first light and has high thermal conductivity, it can dissipate the heat generated at the phosphor member **30** through the base **50**. Securing the part using an Au—Sn solder or the like can reduce the distance from the first light reflecting member **21** to the lower surface of the phosphor member **30** as compared to seam welding or resistance welding, thereby increasing the luminance. For the cover **80**, one made of a light transmissive material, including quartz, silicon carbide, or glass may alternatively be used.

#### Phosphor Member **30**

The phosphor member **30** has a lower surface onto which the first light reflected by the first light reflecting member **21** is irradiated, and an upper surface that serves as the light extraction surface. As shown in FIG. **3**, the phosphor member **30** is secured above the cover **80**.

The phosphor member **30** contains a phosphor that emits fluorescent light when irradiated with the first light. Examples of phosphors include YAG phosphors, LAG phosphors,  $\alpha$ -SiAlON phosphors, and the like. Among all, it is preferable to use a YAG phosphor that is highly heat resistant. The phosphor member **30** is made of an inorganic material. This can improve reliability because the part is more resistant to heat and light as compared to one containing an organic material. For the phosphor member **30** made of an inorganic material, a phosphor ceramic or a phosphor single crystal can be used. An example of a phosphor ceramic includes a sintered body that contains phosphor particles and additives functioning as a binder. In the case of using a YAG phosphor ceramic, aluminum oxide can be used as an additive. A phosphor member containing an organic material may be used as long as it is resistant to the first light.

As shown in FIG. **1** and FIG. **2**, the upper surface of the phosphor member **30** has a shape that is elongated in one direction, and the lower surface of the phosphor member **30** also has a shape that is elongated in one direction. The irradiated region in the lower surface of the phosphor member **30** has a shape that is elongated in one direction. The first LD element **11** and the first light reflecting member **21** are disposed so that the longer sides of the lower surface of the phosphor member **30** is parallel to the longer sides of the irradiated region on the lower surface of the phosphor member **30**. This shortens the distances from the irradiated region to the outer edges of the phosphor member **30** in the lower surface of the phosphor member **30**, thereby facilitating dissipation of the heat generated at the phosphor member **30** through the light shielding member **40**. This can facilitate attenuation of a conversion efficiency decline in the phosphor member **30**. From the perspective of mass production of the phosphor member **30**, the shapes of the upper

surface and the lower surface of the phosphor member **30** shown in FIG. **1** and FIG. **2** are rectangular, but they may be oval.

In the present embodiment, in a plane parallel to the upper surface of the base **50**, the distance from the emission point of the first LD element **11** to the light reflecting area of the first light reflecting member **21** is 0.48 mm. In a plane perpendicular to the upper surface of the base, the distance from the light reflecting point in the first light reflecting member **21** to the lower surface of the phosphor member **30** is 1.3 mm. Moreover, angle A is 33.5 degrees and angle B is 56.5 degrees. At this time, in a plane perpendicular to the upper surfaces of the base **50**, the first region **21a**, and the second region **21b**, the length of the first region **21a** (i.e., the length of the lower oblique surface in the first light reflecting member **21** in FIG. **6**) is 0.36 mm, and the length of the second region **21b** (i.e., the length of the upper oblique surface in the first light reflecting member **21** in FIG. **6**) is 0.6 mm. The lower surface of the phosphor member is 1 mm in the long-side direction and 0.5 mm in the short-side direction.

#### Light Shielding Member **40**

The light shielding member **40** is disposed to surround the lateral surfaces of the phosphor member **30**. In other words, when viewed from above the phosphor member **30**, the light shielding member **40** is disposed to surround the phosphor member **30**. Provision of the light shielding member **40** can reduce light that is released from elsewhere than the upper surface of the phosphor member **30**. The light shielding member **40** is disposed in direct contact with the phosphor member **30**. This can facilitate dissipation of the heat generated at the phosphor member **30** as compared to being bonded by using a material having a relatively low thermal conductivity, such as a resin or glass.

In the case in which the phosphor member **30** contains a YAG phosphor, preferable material for the light shielding member **40** is a ceramic material containing aluminum oxide as a main component. The phosphor member **30** and the light shielding member **40** are directly bonded together by sintering. At this time, voids are present in the regions of the light shielding member **40** in the vicinity of the phosphor member **30**. The light from the phosphor member **30** is less likely to transmit through the light shielding member **40** because it is reflected at the interfaces between the aluminum oxide particles and the voids. Being integrally sintered with the phosphor member and the presence of voids in the vicinity of the phosphor member **30** allow the light shielding member **40** to shield the light from the phosphor member **30** while increasing the adhesion between the phosphor member **30** and the light shielding member **40**. The light shielding member **40** preferably has more voids in the regions in the vicinity of the phosphor member **30** than the regions near the peripheral edges of the light shielding member **40**. In other words, the sintered density in the regions near the phosphor member **30** is preferably lower than the sintered density in the regions near the peripheral edges of the light shielding member **40**. This can attenuate the mechanical strength decline of the light shielding member **40** while attenuating the decline in the reflectance of light from the phosphor member **30**. For the light shielding member **40**, aluminum nitride or the like may alternatively be used instead of aluminum oxide.

#### Second Light Shielding Member **90**

In the case in which the cover is formed of a material comprising a light transmissive material, as shown in FIG. **3**, it is preferable to provide a second light shielding member **90** to cover a portion of the upper surface of the cover **80** and

the lateral surfaces of the cover **80**. This can attenuate the leakage of the first light and the fluorescent light from the lateral surfaces of the cover **80** or the heat dissipater **110** described later. Examples of the materials employed for the second light shielding member **90** include a resin containing light scattering particles such as titanium oxide or the like. Thermistor **100**

As shown in FIG. **5**, the light emitting device **200** includes a thermistor **100**. Because the thermistor **100** enables measurement of the LD element temperature, the electric current supplied to the LD element can be varied in response to temperature change. For example, a ceramic material can be used for the thermistor **100**. The thermistor **100** is disposed on the upper surface of the base **50** using a solder material, such as Au—Sn. The thermistor **100** is electrically connected to the second wiring part **53b** via a wire.

#### Second Embodiment

FIG. **8** is a perspective view of the light emitting device **300** related to a second embodiment. FIG. **9** is a top view of the device in FIG. **8**. FIG. **10** is a top view for illustrating the interior of the recess in the light emitting device **300**, and FIG. **11** is an enlarged view of the section encircled by a dotted line in FIG. **10**. The light emitting device **300** is essentially identical to the light emitting device **200** except for the features described below.

The light emitting device **300** includes a second LD element **12** disposed on the upper surface of the base **50** (i.e., the first upper surface of the base **50** in this embodiment) and emitting second light, and a second light reflecting member **22** disposed on the upper surface of the base **50** and reflecting the second light towards the lower surface of the phosphor member **30**. This can increase the intensity of the light extracted from the phosphor member **30**. The second light reflecting member **22** includes a third region **22a** onto which a portion of the second light is irradiated and a fourth region **22b** disposed farther from the second LD element **12** than the third region **22a** onto which another portion of the second light is irradiated. The third region **22a** and the fourth region **22b** are formed so that the portion of the light reflected by the third region **22a** that is reflected on the side close to the fourth region **22b** and the portion of the light reflected by the fourth region **22b** that is reflected on the side close to the third region **22a** intersect before reaching the lower surface of the phosphor member **30**, to thereby irradiate both end portions in the longitudinal direction of the irradiated region. The second light reflecting member **22** can be structured in the same or a similar manner to the first light reflecting member **21**.

The second LD element **12** is secured to the upper surface of a second submount **62** via a conductive layer, in the same or a similar manner to the first LD element **11**. The second LD element **12** and the second submount **62** can be structured in the same or a similar manner to the first LD element **11** and the first submount **61**, respectively.

As shown in FIG. **10** and FIG. **11**, a plane perpendicular to the emission surface of the first LD element **11** and the upper surface of the base **50** (i.e., the first upper surface of the base in this embodiment) is not parallel to a plane perpendicular to the upper surface of the base **50** and the first region **21a** and the second region **21b** of the first light reflecting member **21**. Moreover, a plane perpendicular to the emission surface of the second LD element **12** and the upper surface of the base **50** is not parallel to a plane perpendicular to the upper surface of the base **50** and the third region **22a** and the fourth region **22b** of the second light

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reflecting member 22. In other words, in a top view, the first LD element 11 and the first light reflecting member 21 are diagonally disposed, and the second LD element 12 and the second light reflecting member 22 are similarly disposed diagonally. In this manner, the light from each LD element can be reflected in a direction other than the direction perpendicular to the upper surface of the base 50 (i.e., in the direction extending from the upper surface of the base 50 to the phosphor member 30) without complicating the light reflecting surface structure in each light reflecting member. This allows the light from two LD elements to irradiate a single phosphor member 30. To explain using FIG. 10, the light from the first LD element 11 irradiates the first light reflecting member 21 from the left side and reflected forward and downward seen as the plane figure and its orientation to irradiate the lower surface of the phosphor member 30, and the light from the second LD element 12 irradiates the second light reflecting member 22 from the right side and reflected forward and upward seen as the plane figure and its orientation to irradiate the lower surface of the phosphor member 30.

As shown in FIG. 11, a plane perpendicular to the emission surface of the first LD element 11 and the upper surface of the base 50 is referred to a first plane P1. A plane perpendicular to the upper surface of the base 50 and the first region 21a and the second region 21b of the first light reflecting member 21 is referred to a second plane P2. The angle defined by the first plane P1 and the second plane P2 is referred to as angle  $\alpha$ , and is preferably in the range of from 10 to 60 degrees. A plane perpendicular to the emission surface of the second LD element 12 and the upper surface of the base 50 is referred to a third plane P3. A plane perpendicular to the upper surface of the base 50 and the third region 22a and the fourth region 22b of the second light reflecting member 22 is referred to a fourth plane P4. The angle defined by the third plane P3 and the fourth plane P4 is referred to as angle  $\beta$ , and is preferably in the range of from 10 to 60 degrees. Setting angle  $\alpha$  and angle  $\beta$  to be 60 degrees at most can make the light reflected by each of the light reflecting members less spreading too much. More effectively, angle  $\alpha$  and angle  $\beta$  are set in the range of from 30 to 40 degrees.

The angle formed by the surface on which the second light reflecting member 22 is disposed (i.e., the upper surface of the base 50 in this embodiment) and the third region 22a of the second light reflecting member 22 is larger than 15 degrees, but smaller than 45 degrees. The angle formed by the upper surface of the base 50 and the fourth region 22b of the second light reflecting member 22 is larger than 45 degrees, but smaller than 75 degrees. This can inhibit the intensity at the center of the irradiated region in the lower surface of the phosphor member 30 from being excessively higher than the intensity near the outer edges.

As shown in FIG. 10 and FIG. 11, the first LD element 11 and the second LD element 12 are disposed so that the emission surface of the first LD element 11 is diagonally opposite from the emission surface of the second LD element 12. In this manner, as shown in FIG. 8 and FIG. 9, the phosphor member 30 can be disposed in the central portion of the light emitting device 300, thereby facilitating relatively uniform dissipation of the heat generated at the phosphor member 30.

FIG. 12 shows a simulated luminous intensity distribution of the first light and the second light irradiated onto the lower surface of the phosphor member 30 in the light emitting device 300, and FIG. 13 is a graph showing the luminous intensity distribution along line XIII-XIII in FIG.

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12. FIG. 14 shows a simulated luminous intensity distribution of the first light irradiated onto the lower surface of the phosphor member 30. The simulation conditions will be explained below with reference to FIG. 10 and FIG. 11.

The first LD element 11, the first light reflecting member 21, and the phosphor member 30 are structured in the same or a similar manner to in the first embodiment. The distance from the emission point of the second LD element 12 to the light reflecting area of the second light reflecting member 22 is 0.64 mm on a plane parallel to the upper surface of the base 50. The angle formed by the upper surface of the base 50 and the third region 22a of the second light reflecting member 22 is 33.5 degrees, the angle formed by the upper surface of the base 50 and the fourth region 22b of the second light reflecting member 22 is 56.5 degrees. Angle  $\alpha$  and angle  $\beta$  are each 34 degrees. At this time, the lengths of the third region 22a and the fourth region 22b in a plane perpendicular to the upper surface of the base 50 in a direction extending from the base 50 to the phosphor member 30, the third region 22a, and the fourth region 22b are 0.36 mm and 0.6 mm, respectively.

As shown in FIG. 14, the intensity distribution of the light from the first LD element 11 is curved in the center of the phosphor member 30. The intensity distribution of the light from the second LD element 12 is curved so as to have line symmetry about an axis that is the lengthwise center line of the phosphor member 30 (i.e., the vertical direction in FIG. 14). In other words, the light emitting device 300 has a structure in which the lights from two semiconductor laser elements do not readily overlap in the center while partially overlapping at both end portions in the longitudinal direction of the irradiated region. It is believed that because this can make the luminous intensity at both end portions of the irradiated region slightly higher than the luminous intensity in the center, light having more uniform emission intensity can be obtained from the phosphor member 30. In this embodiment, the first light reflecting member 21 and the second light reflecting member 22 both have multiple light reflecting surfaces, while the first LD element 11 and the first light reflecting member 21, and the second LD element 12 and the second light reflecting member 22, are diagonally arranged, to thereby allow the first light and the second light to be bent to irradiate the lower surface of the phosphor member 30. In the present embodiment, the luminous intensity at both end portions in the longitudinal direction of the irradiated region is made higher, but the first LD element 11, the first light reflecting member 21, the second LD element 12, and the second light reflecting member 22 may be positioned so that the luminous intensity are nearly equal between the central portion and the end portions.

### Third Embodiment

FIG. 15 is a perspective view of the light emitting device 400 related to a third embodiment. FIG. 16 is a top view of the light emitting device 400. FIG. 17 is a top view for illustrating the interior of the recess in the light emitting device 400. FIG. 18 is an end view taken along XVIII-XVIII in FIG. 16. The light emitting device 400 is essentially identical to the light emitting device 300 except for the features described below.

The light emitting device 400 employs a base that has no second upper surface for the base 50. A cover 80 that includes a metal support 81 and a light transmissive member 82 makes the space in which a first LD element 11 and other components are disposed an airtight space. The support 81 and the light transmissive member 82 are bonded using a

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bonding material **83**. Furthermore, the part of the base **50** that comes into contact with the cover **80** is formed of a material comprising a metal. The support **81** of the cover **80** and the base **50** are secured by soldering so that the light reflected by the first light reflecting member **21** transmits through the light transmissive member **82** of the cover **80**.

The support **81** and the part of the base **50** in contact with the cover **80** are structured with a material comprising iron as a main component. "Containing as a main component" here refers to containing a material in excess of 50% relative to the total weight. The light transmissive member **82** is structured with a material comprising glass. A heat dissipater **110** is further disposed on or above the support **81**, but under the phosphor member **30** and the light shielding member **40**. Example materials of the heat dissipater **110** include sapphire, quartz, or silicon nitride. Sapphire is preferably used for the heat dissipater **110**.

In this embodiment, because the distance between the first light reflecting member **21** and the phosphor member **30** is longer by the thickness of the cover **80**, angle  $\alpha$  and angle  $\beta$  therein are smaller than the angle  $\alpha$  and angle  $\beta$  in the light emitting device **300**. For example, angle  $\alpha$  and angle  $\beta$  are set to 30 degrees. The first light reflecting member **21** and the second light reflecting member **22** each have three light reflecting surfaces.

What is shown is an example of the light emitting device **400** without a thermistor, but the light emitting device **400** may include a thermistor as in the case of the light emitting device **300**.

The light emitting device described in the present disclosure can be used in lighting fixtures, automotive lamps, and the like.

What is claimed is:

1. A light emitting device comprising:

a base;

a first semiconductor laser element disposed on an upper surface of the base and configured to emit first light from a first emission surface perpendicular to the upper surface of the base;

a first light reflecting member disposed on the upper surface of the base, the first light reflecting member having a first light reflecting face configured to reflect the first light;

a second semiconductor laser element disposed on an upper surface of the base and configured to emit second light from a second emission surface perpendicular to the upper surface of the base;

a second light reflecting member disposed on the upper surface of the base, the second light reflecting member having a second light reflecting face configured to reflect the second light; and

a phosphor member onto which the first light reflected from the first light reflecting member and the second light reflected from the second light reflecting member are irradiated, wherein:

in a top view, a first plane perpendicular to the first emission surface and perpendicular to the upper surface of the base is not parallel to a second plane perpendicular to the upper surface of the base and perpendicular to the first light reflecting face,

in a top view, a third plane perpendicular to the second emission surface and perpendicular to the upper surface of the base is not parallel to a fourth plane perpendicular to the upper surface of the base and perpendicular to the second light reflecting face, and

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in a top view, at least a part of the first light reflecting face is positioned between a plane of the first emission surface and a plane of the second emission surface.

2. The light emitting device according to claim 1, wherein the first semiconductor laser element and the second semiconductor laser element are disposed so that the first emission surface is diagonally opposite from the second emission surface.

3. The light emitting device according to claim 1, wherein an angle between the first plane and the second plane is in a range of 10 to 60 degrees, and wherein an angle between the third plane and the fourth plane is in a range of 10 to 60 degrees.

4. The light emitting device according to claim 1, wherein the first light reflected by the first light reflecting face travels in a direction approaching the second semiconductor laser element in a top view, and wherein the second light reflected by the second light reflecting face travels in a direction approaching the first semiconductor laser element in a top view.

5. The light emitting device according to claim 1, wherein, in a top view, the phosphor member is disposed above the first semiconductor laser element and the second semiconductor laser element, and the phosphor member is positioned between the plane of the first emission surface and the plane of the second emission surface.

6. The light emitting device according to claim 1, wherein the first light forms a first irradiated region at an irradiated face of the phosphor member, and wherein an intensity distribution of the first irradiated region has a shape with a first curved portion in the center.

7. The light emitting device according to claim 1, wherein the first light reflecting face comprises a plurality of first light reflecting faces extending in planes having different inclined angles with respect to the upper surface of the base, and

wherein the second light reflecting face comprises a plurality of second light reflecting faces extending in planes having different inclined angles with respect to the upper surface of the base.

8. The light emitting device according to claim 1, wherein at least part of the second light reflecting face is positioned between the plane of the first emission surface and the plane of the second emission surface.

9. The light emitting device according to claim 1, wherein an entirety of the first light reflecting face is positioned between the plane of the first emission surface and the plane of the second emission surface.

10. The light emitting device according to claim 1, wherein the first light traveling to the first light reflecting face travels in a direction approaching the second semiconductor laser element, and the second light traveling to the second light reflecting face travels in a direction approaching the first semiconductor laser element in a top view, and

wherein a shortest length between the first emission surface and the first light reflecting face is less than a shortest length between the first emission surface and the second light reflecting face.

11. The light emitting device according to claim 1, further comprising:

a frame part disposed on the upper surface of the base and surrounding the first semiconductor laser element, the

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second semiconductor laser element, the first light reflecting member and the second light reflecting member.

**12.** The light emitting device according to claim **6**, wherein the first curved portion is positioned at a center of the irradiated face of the phosphor member. 5

**13.** The light emitting device according to claim **6**, wherein the second light forms a second irradiated region at the irradiated face of the phosphor member, wherein an intensity distribution of the second irradiated region has a shape with a second curved portion in the center, and 10

wherein a curved direction of the first curved portion and a curved direction of the second curved portion are opposite. 15

**14.** The light emitting device according to claim **13**, wherein the intensity distribution of the first irradiated region and the intensity distribution of the second irradiated region are axisymmetric with respect to a

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center line parallel to a longitudinal direction of the irradiated face of the phosphor member.

**15.** The light emitting device according to claim **12**, wherein the second light forms a second irradiated region at an irradiated face of the phosphor member, wherein an intensity distribution of the second irradiated region has a shape with a second curved portion at the center, and

wherein a curved direction of the first curved portion and a curved direction of the second curved portion are opposite.

**16.** The light emitting device according to claim **15**, wherein the intensity distribution of the first irradiated region and the intensity distribution of the second irradiated region are axisymmetric with respect to a center line parallel to a longitudinal direction of the irradiated face of the phosphor member.

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